THE CHRONICITY OF COGNITIVE IMPAIRMENT ASSOCIATED WITH EXPOSURE TO TOXIC MOLD

Wayne A. Gordon[1a], Joshua Cantor[1], Heather Charatz[1], Teresa Ashman[1], and Eckardt Johanning[2]

[1]Department of Rehabilitation Medicine, Mount Sinai School of Medicine, New York, NY, U.S.A.
[2]Department of Community and Preventive Medicine, Mount Sinai School of Medicine, New York, NY, U.S.A. Fungal Research Group Foundation, Inc., Albany, NY, U.S.A.
[a]Contact author email: wayne.gordon@mssn.edu

INTRODUCTION

Gordon *et al.* (1999) reported an association between exposure to toxic molds and cognitive impairment. Since then, two other studies (Baldo, Ahmad, Ruff, 2002; Gordon, *et al.* 2004) have offered further support for such an association. While some efforts have been made to examine the chronicity of cognitive symptoms in samples of persons exposed to mold (e.g., Sudakin, 1998), there are no studies in the literature to date which examine patterns of performance over time on comprehensive batteries of neuropsychological tests. Examining chronicity is crucial to determining whether the cognitive impairments found to be associated with mold exposure persist for significant periods of time after exposure has ceased. The present study was conducted in order to begin to address this issue.

METHOD

A group of eight individuals with histories of exposure to toxic mold, who were originally administered a battery of neuropsychological tests by the senior author, were re-tested at an interval of one to five years after the initial testing. All eight were exposed to toxic molds such as *Stachybotrys atra*, *Penicillium*, and *Aspergillus* for varying lengths of time. All exposures were documented by environmental testing conducted during the exposure period. All exposures had ceased by the time of the first testing.

Seven of the eight persons tested were women. At the second testing, they ranged in age from 37 to 65 (M = 49.25, SD = 10.12). Most were college graduates (Mean years of education = 15.75, SD = 1.95). Participants' full scale IQs varied from the average to very superior ranges (M = 116, SD = 11). All eight continued to report symptoms of cognitive impairment at re-testing.

RESULTS

Because group data do not capture the full extent of the chronicity of cognitive impairments in a sample of this size, especially in higher functioning individuals, a brief description of each participant's functioning is provided below. In each case, although impairments were chronic in some domains, there was some fluctuation in test scores between evaluations. Some scores improved, some remained unimpaired, and some worsened. Because a thorough discussion of test and retest scores for each subject is beyond the scope of this paper, we have chosen to focus on domains where chronic impairments (either relative or absolute) were found at re-testing. Key supporting data for chronicity are provided in Table 1:

Participant 1 (Evaluated 1998 and 2002): Participant 1 is a professional with a master's degree. She continued to experience reduced processing speed, memory, and learning difficulties.

Participant 2 (Evaluated 1997 and 2001): Participant 2 graduated from college *cum laude*, with honors in two majors. Until the onset of her cognitive impairments, she worked in a literary field. At re-testing, verbal learning and memory continued to be reduced and verbal memory and IQ remained inconsistent with her levels of academic performance in college. Some difficulties with executive functions also remained at the second testing.

Participant 3 (Evaluated 2001 and 2002): Participant 3 continued to have significant impairments in the domains of attention and concentration and verbal learning at re-evaluation.

Participant 4 (Evaluated 2000 and 2002): On re-testing, Participant 4's test results continued to indicate reduced processing speed on cognitively demanding tasks.

Participant 5 (Evaluated 2001 and 2002): Participant 5's IQ is in the very superior range. Re-testing indicated the continuation of significant impairment on tests of memory function relative to IQ level. Difficulties on tests of executive functions also remained.

Participant 6 (Evaluated 2000 and 2002): At the second testing Participant 6 continued to have significant difficulties on tests of complex visual memory and impaired executive functions.

Participant 7 (Evaluated 1997 and 2002): Participant 7 is a college graduate who has a successful work history in the teaching, management, and financial fields. Re-test findings showed continued decreased intellectual functioning, impaired visual

memory on complex tasks and reduced performance in aspects of executive functioning.

Participant 8 (Evaluated 1997 and 2002): Participant 8's IQ is in the superior range. On re-testing, relative impairments on tests of attention and concentration, visual memory, and verbal encoding were noted to have continued.

In all eight cases, a thorough review of relevant medical history revealed no preexisting problems that could account for the findings of cognitive impairment (e.g., traumatic brain injury, neurological disorders, significant psychiatric history) or for their chronicity.

DISCUSSION

These data indicate that, despite some variations in test findings, all participants continued to experience cognitive impairment one to five years after initial neuropsychological testing and termination of mold exposure. The findings suggest that some cognitive deficits secondary to toxic mold exposure are chronic in this small sample of individuals, even after cessation of mold exposure.

Table 1. Neuropsychological Testing Data[a] from Study Participants Documenting Chronicity of Impairment from Initial Testing to Subsequent Re-testing

Participant	Percentile Scores on Testing 1		Percentile Scores on Testing 2	
1	**Processing Speed**		**Processing Speed**	
	WAIS-III[b] Processing Speed =	21%ile	WAIS-III Processing Speed =	21%ile
			Stroop[c] Word =	3%ile
			Stroop Color =	1%ile
			Trails A[f] =	6%ile
	Memory & Learning		**Memory & Learning**	
	WAIS-III Working Memory =	9%ile	WAIS-III Working Memory =	18%ile
	WMS-III[c] Auditory Immediate =	13%ile	WMS-III Auditory Immediate =	9%ile
	WMS-III Auditory Delayed =	23%ile	WMS-III Auditory Delayed =	23%ile
	WMS-III Auditory Recognition =	25%ile	WMS-III Auditory Recognition =	37%ile
	WMS-III Visual Immediate =	7%ile	WMS-III Visual Immediate =	3%ile
	WMS-III Visual Delayed =	50%ile	WMS-III Visual Delayed =	7%ile
	WMS-III Immediate memory =	5%ile	WMS-III Immediate memory =	3%ile
	WMS-III General memory =	27%ile	WMS-III General memory =	13%ile
	WMS-III Working memory =	5%ile	WMS-III Working memory =	8%ile
	CVLT[d] Trials 1 to 5 =	<1%ile	CVLT Trials 1 to 5 =	2%ile
2	**Intellectual Functioning**		**Intellectual Functioning**	
	WAIS-III Verbal IQ =	82%ile	WAIS-III Verbal IQ =	77%ile
			WAIS-III VIQ < WAIS-III PIQ ($p < .05$)	
	Verbal Learning & Memory		**Verbal Learning & Memory**	
	WMS Verbal Memory Index = 97		Auditory Immediate Memory =	63%ile
	(vs. Visual Memory Index = 135)			
	CVLT Trial 5 =	2%ile		
	CVLT Trials 1 to 5 =	24%ile		
	All other CVLT scores =	16%ile	All CVLT scores =	50%ile
	Executive Functions		**Executive Functions**	
	Booklet category test = Could not complete		Booklet category test =	8%ile

	Percentile Scores on Testing 1	Percentile Scores on Testing 2
	Attention & Concentration	**Attention & Concentration**
	CPT[g] Overall Index = 10.67 (Borderline)	CPT Overall Index = 10.67 (Borderline)
	CPT Confidence Index for	CPT Confidence Index for

	Percentile Scores on Testing 1		Percentile Scores on Testing 2	
3	**Attention & Concentration**		**Attention & Concentration**	
	CPT[g] Overall Index = 10.67 (Borderline)		CPT Overall Index = 10.67 (Borderline)	
	CPT Confidence Index for		CPT Confidence Index for	
	Attentional Problems =	93%	Attentional Problems =	93%
	Verbal Learning		Verbal Learning	
	CVLT Trial 5 =	2%ile	CVLT Trial 5 =	6%ile
	CVLT Long Delay Free Recall =	2%ile	CVLT Long Delay Free Recall =	6%ile
4	**Processing Speed**		**Processing Speed**	
	All PASAT[h] Scores	< 1%ile	All PASAT Scores	< 2%ile
	WAIS-III Processing Speed Index =	21%ile		
	Purdue pegboard scores =	<2%ile		
5	**Memory**		**Memory**	
	All WMS-III indexes except Working memory		WMS-III Verbal Immediate and Delayed Memory	
	< WAIS-III VIQ ($p < .05$).		< WAIS-III VIQ ($p < .05$).	
	All CVLT scores =	16 or 18%ile	WMS-III Visual Immediate and Delayed Memory	
			< WAIS-III PIQ ($p < .05$).	
	Executive Functions		**Executive Functions**	
	Booklet category Test =	42%ile	Booklet category Test =	1%ile
			Trails B =	50%ile
	Stroop Color/Word =	65%ile	Stroop Color/Word =	58%ile
6	**Visual Memory**		**Visual Memory**	
	WMS-III Visual Immediate and Visual Delayed		All Rey Complex Figure scores =	<1%ile
	< than FSIQ ($p < .05$)			
	CVLT Trials 1 to 5	< 16%ile		
			Executive Functions	
	Executive Functions		Watson Glaser =	5%ile
	Watson Glaser[i] =	25%ile	IOWA[k] reading comprehension =	30%ile
	Booklet category test =	4%ile	(extra time required)	

	Percentile Scores on Testing 1		Percentile Scores on Testing 2	
7	**Intellectual Functioning**		**Intellectual Functioning**	
	WAIS-R[l] PIQ =	27%ile	WAIS-III PIQ =	34%ile
	Visual Memory		**Visual Memory**	
	WMS-R[m] Visual Reproduction =	10%ile	Rey Complex Figure = (Immediate & Delayed)	<1%ile
	Executive Functions		**Executive Functions**	
			IOWA reading comprehension =	16%ile
			IOWA reading efficiency =	6%ile
	Watson Glaser =	3%ile	Watson Glaser =	10%ile
	Booklet category test = Could not complete		Stroop Color Word =	24%ile
8	**Attention & Concentration**		**Attention & Concentration**	
	WMS-R Attention/ Concentration Index Score =	89	CPT Clinical Significant Attention Problem, Confidence Index =	99.9%
	Visual Memory		**Visual Memory**	
	WMS-R Visual Memory Index =	113	WMS-III Visual Immediate Memory < WMS-III Auditory and Visual Delayed Memory ($p < .05$)	
	Verbal Encoding		**Verbal Encoding**	
	CVLT Trial 1 =	50%ile	CVLT Trial 1 =	50%ile

[a]Only data indicative of significant impairments (absolute or relative) where performance in the given domain did not change significantly from Testing 1 to Testing 2 are included, [b] Wechsler Adult Intelligence Scale - Third Edition, [c] Wechsler Memory Scale - Third Edition, [d] California Verbal Learning Test, [e] Stroop Color Word Test, [f] Trail Making Test - Part A, [g] Conners Continuous Performance Test, [h] Paced Auditory Serial Attention Task, [i] Trail Making Test - Part B, [j] Watson Glaser Critical Thinking Appraisal - Form B, [k] Iowa Silent Reading Test, [l] Wechsler Adult Intelligence Scale - Revised, [m] Wechsler Memory Scale - Revised

REFE

- Bald patie
- Gor with *ins*
- Occ
- Gor Had fung *New*
- Suda stud

REFERENCES

- Baldo, J. V., Ahmad, L., & Ruff, R., 2002, "Neuropsychological performance of patients following mold exposure", *Applied Neuropsychology*, 9(4), 193-202.
- Gordon, W. A., Johanning, E., Haddad, L., 1999, "Cognitive impairment associated with exposure to toxigenic fungi", In Johanning, E. (Ed.), *Bioaerosols, fungi and mycotoxins: Health effects, assessment, prevention and control.* New York: Eastern New York Occupational and Environmental Health Center.
- Gordon, W. A., Cantor, J. B., Johanning, E., Charatz, H. J., Ashman, T. A., Breeze, J., Haddad, L., Abramowitz, S. 2004, "Cognitive impairment associated with toxigenic fungal exposure: A replication and extension of previous findings", *Applied Neuropsychology*, 11(2): 65-74.
- Sudakin, D. L., 1998, "Toxigenic fungi in a water-damaged building: An intervention study", *American Journal Of Industrial Medicine*, 34 (2): 183-190.